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The U.S. EPA's National Risk Management Research Laboratory (NRMRL) Air Pollution Prevention and Control Division (APPCD), formerly EPA's Air and Energy Engineering Research Laboratory (AEERL), is cooperating with the Research Triangle Institute (RTI) to demonstrate that converting wood energy to electrical power results in waste utilization, pollution alleviation, and energy conservation.

The project is expected to demonstrate the technical, economic, and environmental feasibility of an innovative energy conversion technology, producing approximately 1 MWe, at the Marine Corps Base, Camp Lejeune, NC. Camp Lejeune will supply wood waste for power plant operation while minimizing transport and maximizing local waste resource utilization. The technology for the process and the site at Camp Lejeune have been selected, design specifications are presently underway, and installation, start-up, testing, and demonstration will soon follow. This paper provides details of the status of this project.

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DEMONSTRATION OF A 1 MWe BIOMASS POWER PLANT

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Abstract

The U.S. Environmental Protection Agency's (EPA's) National Risk Management Research Laboratory (NRMRL) Air Pollution Prevention and Control Division (APPCD), formerly EPA's Air and Energy Engineering Research Laboratory (AEERL), is cooperating with the Research Triangle Institute (RTI) to demonstrate that converting wood energy to electrical power results in waste utilization, pollution alleviation, and energy conservation.

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"This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication."

Introduction

Utilizing biomass as a fuel for power generation will eliminate sulfur dioxide (SO_2) emissions, produce zero net gain of carbon dioxide (CO_2), reduce air toxic emissions, and help solve waste disposal problems. Additional benefits from fueling a power generation system with biomass are savings from avoiding transportation and tipping fees for disposal of biomass residues in a landfill, savings from decreasing or eliminating the purchase of fossil fuels and/or electricity, possible tax credits, and energy security from using indigenous biomass for fuel. EPA biomass energy projects are intended to provide the impetus needed for the development of equipment, design of systems, creation of markets, and promotion of exportable technologies.

The objective of this project is to demonstrate that an innovative energy conversion technology fueled with biomass is technically, economically, and environmentally feasible for Camp Lejeune and other Department of Defense (DoD) installations, industrial sites, and developed and developing countries. The approach has been to identify a site, the partners, and the most viable technology, then design, build, and test the technology. The coordination between DoD and the partners has been such that the design of the project is in the best interest of Camp Lejeune. The technical risks have been minimized by the proper selection of technology based on the available site, size of system, type of fuel, qualifications of operators, and lessons learned by all cooperators.

Converting wood to power at military installations will result in waste utilization, alleviation of pollution, and energy conservation. This is a real contribution toward meeting Federal directives to stabilize CO_2 emissions at 1990 levels by the year 2000, and to reduce Federal agencies' energy consumption to 20% below 1991 levels by the year 2000 (Executive Order 12759). The project also has excellent potential for technology transfer to the commercial sector and other public agencies which follows a trend of revived commercial interest in wood energy and growth of independent power production and industry-site power plants.

Demonstration Site and Fuel

The Camp Lejeune Energy from Wood (CLEW) project is intended to demonstrate a biomass-to-energy conversion technology at a scale of approximately 1 MW of electrical output, on the Marine Corps Base in North Carolina. Camp Lejeune is located in the Coastal Plain of North Carolina and occupies approximately 153,000 acres ($6.2 \times 10^8 m^2$). The Base has 45,000 active duty personnel, 4,500 civilian employees, and about 12,000 dependents. The Base utility is about 30 to 40 MW, with peak summer demand reaching a maximum 70 MW. The 1 acre (4047 m^2) site at the Camp Lejeune Piney Green Industrial Area has been selected for the project facility. The site has easy access to all necessary utilities, is in close proximity to the landfill, and is secluded from the main section of the Base.

The biomass fuel for the demonstration will be generated by activities on the Base. Over 22,000 tons per year (tpy) (19,958 metric tpy) of combined wood products and tree limbs are available. Most of the waste is currently being landfilled, and a waste recovery program is sought that will be of benefit to the Base. The waste will become the fuel for the demonstration and will be delivered in chipped or hogged fuel-size to the demonstration site by Base operations. It is estimated that up to 90% of this waste will be used for the demonstration plant. Fuel preparation will include metal and other trash removal, and grinder operating conditions for optimum fuel size.

Technology

Mech-Chem Associates, Inc. of Norfolk, MA, in conjunction with Thermal Technologies, Inc. (TTI) of Omaha, NE, was selected to provide the technology to be demonstrated. The Mech-Chem technology consists of an atmospheric fixed-bed down-draft gasifier, gas cleaning components, and spark-ignited engines.

A down-draft gasifier is used to produce synthetic fuel gas. The synthesis gas exits the gasifier and flows through a cyclone, heat exchangers, gas/liquid separators, and cartridge filters. The suction in the system is created by passing the gas through a multistage centrifugal blower. The blower discharges the gas into a spark-ignited and diesel engine-generator set.

Design

Preliminary design for the system has been completed by Mech-Chem and RTI, and design review is presently underway. The process flow diagram is shown in Figure 1. Considerations in designing the overall process for the demonstration include fuel handling, fuel drying, reaction, gas stream cleanup, fuel sampling, and the engine generator sets. RTI is performing the design on fuel handling, fuel drying, and fuel sampling, while Mech-Chem is providing the design of the reactor, gas stream cleanup, and engine generator sets.

The fuel drying for the process will be performed in a deep bed dryer. The chipped wood fuel will be fed to the dryer by a walking floor trailer at a rate of approximately 2500 lb/hr (1134 kg/hr). Hot engine exhaust at 400°F (204°C) will be used to dry the wood, and it will be pulled through the bed at a rate of 5000 SCFM (2.45 m^3/sec). The wet fuel at approximately 45% moisture will be dried in the deep bed dryer to 10% moisture. Tests have been performed by RTI to confirm the drying rate, retention time, and pressure drop associated with the deep bed dryer. The hot exhaust will be pulled through the dryer by a 5 HP (3.7 kW) blower, and a cyclone will separate fines entrained in the air stream leaving the dryer. The fuel will be metered by the dryer as needed to keep the feed hopper full for the pyrolysis reactor. The fuel will be conveyed from the hopper to a surge bin which directly feeds the pyrolysis reactor as indicated by the leveling arm in the reactor.

Pyrolysis reactor PR-20 converts wood chip fuel into a low heat value gas. The wood chip fuel is fed into the reactor by a surge hopper located at the top of the rector, and preheated air for combustion is fed from heat exchanger HX-45. The preheated air that enters the reactor will only partially combust the fuel. The heat from the combustion is transferred to the wood, driving off the volatile gases by pyrolysis. The result of this pyrolysis is an activated carbon "char" bed and a low heat value gas. The char is removed from the bottom of the reactor by a screw conveyor and is collected in carbon hopper CH-40. The activated carbon is potentially a saleable by-product of the system.

Cyclone CS-50 removes the particulates from the stream initially. The stream is then cooled to 100°F (38°C) by heat exchangers HX-55 and HX-65, and liquids are separated out by vertical liquid/gas separators LS-60 and LS-70. The 10 μm cartridge filters F-75 and F-76 further remove tars and particulates before the gas reaches blower B-80. The low heat value "syngas" is pulled through the system by blower B-80. The final stage of gas cooling and cleanup includes heat exchanger HX-85 and liquid separator LS-90 where the gas is dropped back to 100°F (38°C) and final liquid separation takes place.

After all tars and particulates are sufficiently removed in the cleanup phase of the process, the gas is monitored and fed to two engine-generator sets to produce 1 MW of electricity. The gas is monitored continuously for constituents such as nitrogen, hydrogen, carbon monoxide, carbon dioxide, and methane. The continuous monitoring of the gas stream will allow for overall process analysis. The gas is finally fed to the two engines. One engine is a diesel compression engine and the other a spark-ignited engine. The efficiency and reliability of the two engines will be compared.

Design Tests

The gasification technology of Mech-Chem Associates is presently in operation at Ellicottville Energy Plant in Ellicottville, NY. The design of this facility differs from the design of the CLEW project in three ways: the facility is not operated continuously, it is manually operated, and it is fueled with sawdust pellets. The CLEW project is to be operated continuously; it is to be fully automated, utilizing a personal computer; and it is to be fueled with wood chipped with a tub grinder. Despite the differences between the design of the Ellicottville Energy Plant and the preliminary design of the CLEW project, a test operation of the Ellicottville Energy Plant would aid in the final design phase of the CLEW project.

RTI performed a test of the Ellicottville Energy Plant in June of 1995. Wood for the test was obtained locally and processed through a tub grinder to match the charateristics of the wood that will be used to fuel the CLEW project. The main objective of the test was to observe how Mech-Chem's technology operates with the chipped wood typical of that from Camp Lejeune's landfill, as opposed to pelletized sawdust. Several modifications to the fuel handling system at the facility were made due to the larger, less uniform chips, and a gas chromatograph was installed upstream from the engines to continuously monitor the components of the syngas. However, the gasification process and cleanup train was operated under normal conditions. The particular points of interest for observation included the fuel composition and quality, the amount of tars produced and their

composition, the amount of water removed by the liquid separators, the char quality, the pressure drop through the system, reactor temperatures, and overall system performance.

Project Schedule

The cooperative agreement between EPA and RTI was signed on July 12, 1994, with a project period of 3 years. The site was selected in the fall of 1994, and the technology was selected in the winter of 1994. Agreements between RTI and TTI were signed, and system design began in the spring of 1995. Site preparation at Camp Lejeune and equipment deliveries to the site should begin in the summer of 1995. Installation should be completed in the winter of 1995. Testing and demonstration should be completed by summer of 1997.

Acknowledgments

This project became a reality due to initial funding from the Department of Defense's (DoD's) Strategic Environmental Research and Development Program (SERDP), and funding and participation from the EPA's NRMRL, RTI, and North Carolina Department of Commerce's Energy Division.

Figure 1. Process flow diagram